experience of several years showed that there was something like an annual inequality of level. There were sometimes changes through 2″ or 3″ which took place in a few hours.

At Geneva M. Plantamour has been making observations concerning variations of the plumb-line, by means of delicate levels, and has arrived at results in general accordance with those of M. d'Abbadie.

The experiments of the authors present a general confirmation of these conclusions, and show that the earth's surface is in a state of continual movement.

With reference to this continual oscillation the authors adduce an experiment which was commenced about three and a half years ago by Mr. Horace Darwin at Down, in Kent. The experiment was undertaken in connection with Mr. Darwin's investigation of the geological activity of earthworms. There are two stout metal rods, one of iron and the other of copper. The ends were sharpened, and they were hammered down vertically about eight feet deep into the soil, and they are in contact with one another, or nearly so. The ends were then cut off about three inches above the ground.

A stone was obtained like a small grindstone, with a circular hole in the middle. This stone was laid on the ground with the two metal rods appearing through the hole. An arrangement with a micrometer screw enables the observer to take contact measurements of the position of the upper surface of the stone with regard to the rods. The stone has, on the whole, always continued to fall, but the general descent can only be gathered from observations taken at many months apart, for it is found to be in a state of continual vertical oscillation.

The measurements are so delicate that the raising of the stone produced by one or two cans full of water poured on the ground can easily be perceived. The effect of frost and the wet season combined is strongly marked, for on January 23, 1881, the stone was 4·12 mm. higher than it had been on September 7, 1880. The prolonged drought of the present summer has had a great effect, for between May 8 and June 29 the stone sank through 5·79 mm.

The changes produced in the height of the stone are, of course, entirely due to superficial causes; but the amounts of the oscillations are certainly surprising, and although the basements of astronomical instruments may be very deep, they cannot entirely escape from similar oscillations.

The last part of the paper contains a discussion of the present aspects of the question, and a criticism of the various forms of instrument which have been used hitherto for the detection of small variations in the position of the plumb-line.

The authors suggest that greater precautions should be taken in the protection of the piers of transit instruments from changes of temperature, and in the drainage of the soil round the basements of the piers; they also draw attention to the disturbing effect of the weight of the observer's body. They express a hope that systematic observations of changes of level may be undertaken at a number of observatories by some instrument analogous to that with which they are working. They are still prosecuting their experiments, and they are in hopes of being able to reduce their instrument to a convenient form, so that it may not be difficult to transport or to erect.

In conclusion they state that they have no hope of being able to observe the lunar attraction in the present site of observation, but they think it possible that they may devise a portable instrument which shall be amply sensitive enough for such a purpose, if the bottom of a deep mine should be found to give a sufficiently invariable support for the instrument.

AN ERROR IN THE COMMONLY ACCEPTED THEORY OF CHEMISTRY

At a public meeting of the University College Chemical and Physical Society Prof. A. W. Williamson, F.R.S., gave an address on "An Error in the Commonly Accepted Theory of Chemistry."

He began by saying that he had been frequently struck by the fact that two theories believed at one time to be conflicting had often been shown by the progress of study to be both true. As an instance in point he took the rival theories, one of which represented molecules as constituted after the pattern of three or four types, while the other viewed them as containing complex groups called radicles.

There was at one time opposition between those who made use of atomic weights and those who employed equivalent weights; the most important slip that has of late been taken is the introduction of the notion of equivalence into the atomic theory; an inspection of the series HCl, H_2O, H_3N, H_4C showed that the atom of chlorine has a different value to that of oxygen, nitrogen, or carbon; thus ammonia may be viewed as being formed by replacing three atoms of chlorine in three molecules of hydric chloride by one atom of nitrogen. Thus nitrogen was said to be trivalent or a triad, and other elements, such as phosphorus, boron, &c., were found to resemble it in this respect; oxygen was called a dyad, and it was found that sulphur, calcium, &c., might also be classed as divalent; in short every element might be placed in one or other of the groups, monad, dyad, triad, &c. That an element can belong to one only of these groups was the view still held by one distinguished chemist, who, for instance, said that nitrogen was trivalent only, and that in sal-ammoniac it was not pentavalent, but that the body in question was a molecular compound of two chemical compounds, ammonia and hydric chloride.

He (Prof. Williamson) thought this was little else than a return to Berzelius' mode of representing compounds, though it was open to an objection from which the theory of the Swedish chemist was free; for Berzelius said that the force which united the two molecules that made up the compound molecule was identical with that which held together the atoms of the constituent molecules, the force being in each case electrical; whereas Prof. Kekulé assumes the forces in the two cases to differ, the one being molecular, and the other chemical.

Now as long as we knew neither of these forces, he (Prof. Williamson) thought it hazardous to assert that there was a difference between them. A study of the evolution of heat in chemical processes threw some light on the subject; Berthelot and Thomsen had shown that when you placed a number of substances within the influence of one another, that reaction or decomposition took place which could evolve the most heat, and we must take into account not merely the heat given out by what we considered the purely chemical process, but also that due to the passage of the product from one state of aggregation to another—from the liquid to the solid state when a precipitate was formed.

Thus the chemical process was determined by the heat due to the chemical reaction plus that due to change of physical condition; and this indicated an identity between chemical and physical force. We might learn the same lesson from Deville's truly remarkable researches on dissociation or strictly reversible decompositions. Thus calcic carbonate was decomposed by heat into lime and carbonic acid, but no sooner was the temperature sufficiently lowered than the two recombined; so, when water was heated, the molecules were separated and formed steam, but on lowering the temperature they recombined to produce water. Ice, water, and steam had in many respects different properties—differences in specific gravity, specific heat, refractive power, &c., quite analogous to those which were found between different chemical compounds.

We had therefore no grounds for assuming a difference between chemical and physical force; Kekulé's theory that an atom can have one, and only one, atomic value was no longer tenable, for it involved the assumption of molecular compounds. The theory commonly in vogue was that atoms vary in their value within certain narrow limits; that nitrogen, for instance, was either trivalent or pentavalent. It had even been asserted that the combining power of an atom was independent of the nature of the elements with which it combined; in the words of a very distinguished chemist, "No matter what the character of the uniting atoms may be, the combing power of the attracting element is always satisfied by the same number of these atoms." This view appeared to him (Prof. Williamson) to have been due to a habit of mind naturally prevailing in many studies, but which, he thought, we had found reason in our scientific work to abandon—he meant the absolute as opposed to the relative.

Prof. Williamson then went on to say that he knew of no limitation to atomic value; he did not say there were no limitations, but he did know that many elements have atomic values greater than those commonly assumed.

We found that the character of the atoms materially affected the result; thus gold could not combine with more than three atoms of chlorine alone, but it could take up an additional atom of chlorine if supplied with an atom of sodium at the same time. In this way we got the common double chloride of gold and sodium, $NaAuCl_4$, in which the gold is pentavalent.

We were not to consider the sodium as being here combined

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with gold as such, it is combined with the whole group $AuCl_4$, a radicle that is doubtless far more chlorous than chlorine itself.

If any were inclined to doubt the truth of this view, they should write the formula $ClNH_4$ under $NaAuCl_4$, when they would perceive that the radicle $AuCl_4$ corresponded to NH_4, ammonium, the basylous properties of which no one doubted nowadays.

In ammonium we have the basylous energies of four hydrogen atoms concentrated by the inert nitrogen, and the result was a powerfully basylous radicle; in $AuCl_4$ we have the chlorous energies of four chlorine atoms giving a powerfully chlorous radicle.

Among other examples of the kind the Professor cited:

$$K_2AsF_7 \text{ with nonovalent atom.}$$
$$\left.\begin{array}{l}K_2PtCl_6\\K_2SiF_6\end{array}\right\}\text{ with octovalent atoms.}$$
$$\left.\begin{array}{l}OI(OH)_5\\KSbF_6\end{array}\right\}\text{ with heptavalent atoms.}$$
$$\left.\begin{array}{l}K_2FeF_4\\K_2MgBr_4\\K_2CuCl_4\end{array}\right\}\text{ with hexavalent atoms.}$$
$$KMgCl_3 \text{ with tetravalent atoms.}$$

And he concluded his address by drawing attention to the conditions that affect the atomic value of an element, which he said were, firstly, the nature of the combining atoms: there was a limit to the number of atoms of one kind that can combine with a given element, but if the element combined at the same time with one or more atoms of a different character, this limit might be passed; and secondly, the temperature, a sufficient rise of temperature being always accompanied by a diminution of atomic value. He thought it of great importance that these points should be considered by those who had artificially limited their horizon. The properties of many of the atoms in complex substances having been in great measure concealed from view by the practice of giving specific names, such as the word "molecular," he thought it would be much better to say at once that we are ignorant of the constitution of these bodies than to resort to such names.

JURASSIC BIRDS AND THEIR ALLIES[1]

ABOUT twenty years ago two fossil animals of great interest were found in the lithographic slates of Bavaria. One was the skeleton of *Archæopteryx*, now in the British Museum, and the other was the *Compsognathus* preserved in the Royal Museum at Munich. A single feather, to which the name *Archæopteryx* was first applied by Von Meyer, had previously been discovered at the same locality. More recently another skeleton has been brought to light in the same beds, and is now in the Museum of Berlin. These three specimens of *Archæopteryx* are the only remains of this genus known, while of *Compsognathus* the original skeleton is, up to the present time, the only representative.

When these two animals were first discovered they were both considered to be reptiles by Wagner, who described *Compsognathus*, and this view has been held by various authors down to the present time. The best authorities, however, now agree with Owen that *Archæopteryx* is a bird, and that *Compsognathus*, as Gegenbaur and Huxley have shown, is a Dinosaurian reptile.

Having been engaged for several years in the investigation of American Mesozoic birds, it became important for me to study the European forms, and I have recently examined with some care the three known specimens of *Archæopteryx*. I have also studied in the Continental museums various fossil reptiles, including *Compsognathus*, which promised to throw light on the early forms of birds.

During my investigation of *Archæopteryx* I observed several characters of importance not previously determined, and I have thought it might be appropriate to present them here. The more important of these characters are as follows:—

1. The presence of true teeth, in position, in the skull.
2. Vertebræ biconcave.
3. A well-ossified broad sternum.
4. Three digits only in the manus, all with claws.
5. Pelvic bones separate.
6. The distal end of fibula in front of tibia.
7. Metatarsals separate, or imperfectly united.

These characters, taken in connection with the free metacarpals and long tail, previously described, show clearly that we have in *Archæopteryx* a most remarkable form, which, if a bird, as I believe, is certainly the most reptilian of birds.

If now we examine these various characters in detail, their importance will be apparent.

The teeth actually in position in the skull appear to be in the the premaxillary, as they are below or in front of the nasal aperture. The form of the teeth, both crown and root, is very similar to the teeth of *Hesperornis*. The fact that some teeth are scattered about near the jaw would suggest that they were implanted in a groove. No teeth are known from the lower jaw, but they were probably present.

The presacral vertebræ are all, or nearly all, biconcave, resembling those of *Ichthyornis* in general form, but without the large lateral foramina. There appear to be twenty-one presacral vertebræ, and the same, or nearly the same, number of caudals. The sacral vertebræ are fewer in number than in any known bird, those united together not exceeding five, and probably less.

The scapular arch strongly resembles that of modern birds. The articulation of the scapula and caracoid, and the latter with the sternum is characteristic; and the furculum is distinctly avian. The sternum is a single broad plate, well ossified. It probably supported a keel, but this is not exposed in the known specimens.

In the wing itself the main interest centres in the manus and its free metacarpals. In form and position these three bones are just what may be seen in some young birds of to-day. This is an important point, as it has been claimed that the hand of *Archæopteryx* is not at all avian, but reptilian. The bones of the reptile are indeed there, but they have already received the stamp of the bird.

One of the most interesting points determined during my investigation of *Archæopteryx* was the separate condition of the pelvic bones. In all other known adult birds, recent and extinct, the three pelvic elements—ilium, ischium, and pubis, are firmly anchylosed. In young birds these bones are separate, and in all known Dinosaurian reptiles they are also distinct.

In birds the fibula is usually incomplete below, but it may be co-ossified with the side of the tibia. In the typical Dinosaurs, *Iguanodon*, for example, the fibula at its distal end stands in front of the tibia, and this is exactly its position in *Archæopteryx*, an interesting point not before seen in birds.

The metatarsal bones of *Archæopteryx* show, on the outer face at least, deep grooves between the three elements, which imply that the latter are distinct, or unite late together. The free metacarpal and separate pelvic bones would also suggest distinct metatarsals, although they naturally would be placed closely together, so as to appear connate.

Among other points of interest in *Archæopteryx* may be mentioned the brain-cast, which shows that the brain, although comparatively small, was like that of a bird, and not that of a Dinosaurian reptile. It resembles in form the brain-cast of *Laopteryx*, an American Jurassic bird, which I have recently described. The brain of both these birds appears to have been of a somewhat higher grade than that of *Hesperornis*, but this may have been due to the fact that the latter was an aquatic form, while the Jurassic species were land birds.

As the *Dinosauria* are now generally considered the nearest allies to birds, it was interesting to find in those investigated many points of resemblance to the latter class. *Compsognathus*, for example, shows in its extremities a striking similarity to *Archæopteryx*. The three clawed digits of the manus correspond closely with those of that genus; although the bones are of different proportions. The hind feet also have essentially the same structure in both. The vertebræ, however, and the pelvic bones of *Compsognathus* differ materially from those of *Archæopteryx*, and the two forms are in reality widely separated. While examining the *Compsognathus* skeleton, I detected in the abdominal cavity the remains of a small reptile which had not been previously observed. The size and position of this inclosed skeleton would imply that it was a fœtus; but it may possibly have been the young of the same species, or an allied form, that had been swallowed. No similar instance is known among the Dinosaurs.

A point of resemblance of some importance between birds and Dinosuurs is the clavicle. All birds have those bones, but they have been considered wanting in Dinosaurs. Two speci-

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[1] Read by Prof. O. C. Marsh before Section D, British Association, at York, September 2, 1881. Communicated by the Author.

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